

# A Robust Technique for Remote Sensing Image Enhancement based on Gaussian and Laplacian Pyramid Fusion with DWT

<sup>1</sup>Zia Ali, <sup>2</sup>Dr. Vineeta Saxena Nigam

<sup>1,2</sup>Dept. of Electronics and Communication Engineering, UIT-RGPV, Bhopal, India

## Abstract

Remote sensing image enhancement techniques have been widely used in many applications of image processing where the subjective quality of images is important for human interpretation. Contrast is an important factor in any subjective evaluation of image quality. Contrast is the difference in luminance that makes an object (or its representation in an image or display) distinguishable. Many algorithms for accomplishing contrast enhancement have been developed and applied to problems in image processing. This project presents a contrast enhancement approach based on enhancing the Gaussian and Laplace pyramidal with DWT based LL sub-band of an image on the input image. This LL sub band then undergoes further decomposition and enhancement using various techniques. The decomposed image is reconstructed and fused together. The HH, HL, LH sub band will also be enhanced by using the techniques already mentioned in literature. After the required processing an image final reconstructed with contrast-limited adaptive histogram equalization that is the final output of the image. The result of proposed method is better as compare to other methods like Standard HE, RMSHE GC-CHE, Demirel's method in terms of image enhancement factor (EME). The proposed work is simulate on matlab R 2012b. The performance of the proposed method will be evaluated using visual assessment and quantitative measures for contrast, luminance and saturation.

## Keywords

Gaussian Pyramidal, Laplacian Pyramidal, Discrete Wavelet Transform (DWT), Histogram Equalization (HE), Enhancement Measurement (EME).

## 1. Introduction

We perceive the surrounding world through our five senses. Some senses (touch and taste) require contact of our sensing organs with the objects. However, we acquire much information about our surrounding through the senses of sight and hearing which do not require close contact between the sensing organs and the external objects. In another word, we are performing Remote Sensing all the time.

Generally, remote sensing refers to the activities of recording/observing/perceiving (sensing) objects or events at far away (remote) places. In remote sensing, the sensors are not in direct contact with the objects or events being observed. The information needs a physical carrier to travel from the objects/events to the sensors through an intervening medium. The electromagnetic radiation is normally used as an information carrier in remote sensing. The output of a remote sensing system is usually an image representing the scene being observed. A further step of image analysis and interpretation is required in order to extract useful information from the image. The human visual system is an example of a remote sensing system in this general sense.

In a more restricted sense, remote sensing usually refers to the technology of acquiring information about the earth's surface (land and ocean) and atmosphere using sensors onboard airborne

(aircraft, balloons) or space borne (satellites, space shuttles) platforms.

Remote sensing can be defined as any process whereby information is gathered about an object, area or phenomenon without being in contact with it. Our eyes are an excellent example of a remote sensing device. We are able to gather information about our surroundings by gauging the amount and nature of the reflectance of visible light energy from some external source (such as the sun or a light bulb) as it reflects off objects in our field of view. Contrast this with a thermometer, which must be in contact with the phenomenon it measures, and thus is not a remote sensing device.



Fig. 1: Shows the fusion based image enhancement

Given this rather general definition, the term remote sensing has come to be associated more specifically with the gauging of interactions between earth surface materials and electromagnetic energy. However, any such attempt at a more specific definition becomes difficult, since it is not always the natural environment that is sensed (e.g., art conservation applications), the energy type is not always electromagnetic (e.g., sonar) and some procedures gauge natural energy emissions (e.g., thermal infrared) rather than interactions with energy from an independent source.

The modern discipline of remote sensing arose with the development of flight. The balloonist G. Tournachon (alias Nadar) made photographs of Paris from his balloon in 1858. Messenger pigeons, kites, rockets and unmanned balloons were also used for early images. With the exception of balloons, these first, individual images were not particularly useful for map making or for scientific purposes.

Systematic aerial photography was developed for military surveillance and reconnaissance purposes beginning in World War I and reaching a climax during the Cold War with the use of modified combat aircraft such as the P51, P38, RB66 and the F4C, or specifically designed collection platforms such as the U2/TR1, SR71, A5 and the OV1 series both in overhead and standoff collection. A more recent development is that of increasingly

smaller sensor pods such as those used by law enforcement and the military, in both manned and unmanned platforms. The advantage of this approach is that this requires minimal modification to a given airframe. Later imaging technologies would include Infrared, conventional, Doppler and synthetic aperture radar.

The development of artificial satellites in the latter half of the 20th century allowed remote sensing to progress to a global scale as of the end of the Cold War. Instrumentation aboard various Earth observing and weather satellites such as Landsat, the Nimbus and more recent missions such as RADARSAT and UARS provided global measurements of various data for civil, research, and military purposes. Space probes to other planets have also provided the opportunity to conduct remote sensing studies in extraterrestrial environments, synthetic aperture radar aboard the Magellan spacecraft provided detailed topographic maps of Venus, while instruments aboard SOHO allowed studies to be performed on the Sun and the solar wind, just to name a few examples.

Recent developments include, beginning in the 1960s and 1970s with the development of image processing of satellite imagery. Several research groups in Silicon Valley including NASA Ames Research Center, GTE, and ESL Inc. developed Fourier transform techniques leading to the first notable enhancement of imagery data. In 1999 the first commercial satellite (IKONOS) collecting very high resolution imagery was launched.

## II. Fundamental Considerations

### A. Spectral Response Patterns

A spectral response pattern is sometimes called a signature. It is a description (often in the form of a graph) of the degree to which energy is reflected in different regions of the spectrum. Most humans are very familiar with spectral response patterns since they are equivalent to the human concept of color.

The eye is able to sense spectral response patterns because it is truly a multi-spectral sensor (i.e., it senses in more than one place in the spectrum). Although the actual functioning of the eye is quite complex, it does in fact have three separate types of detectors that can usefully be thought of as responding to the red, green and blue wavelength regions. These are the additive primary colors, and the eye responds to mixtures of these three to yield a sensation of other hues.

### B. Multispectral Remote Sensing

In the visual interpretation of remotely sensed images, a variety of image characteristics are brought into consideration: color (or tone in the case of panchromatic images), texture, size, shape, pattern, context, and the like. However, with computer-assisted interpretation, it is most often simply color (i.e., the spectral response pattern) that is used. It is for this reason that a strong emphasis is placed on the use of multispectral sensors (sensors that, like the eye, look at more than one place in the spectrum and thus are able to gauge spectral response patterns), and the number and specific placement of these spectral bands.

### C. Hyperspectral Remote Sensing

In addition to traditional multispectral imagery, some new and experimental systems such as AVIRIS and MODIS are capable of capturing hyperspectral data. These systems cover a similar wavelength range to multispectral systems, but in much narrower bands. This dramatically increases the number of bands (and thus precision) available for image classification (typically tens and even hundreds of very narrow bands). Moreover, hyperspectral

signature libraries have been created in lab conditions and contain hundreds of signatures for different types of land covers, including many minerals and other earth materials. Thus, it should be possible to match signatures to surface materials with great precision. However, environmental conditions and natural variations in materials (which make them different from standard library materials) make this difficult. In addition, classification procedures have not been developed for hyperspectral data to the degree they have been for multispectral imagery. As a consequence, multispectral imagery still represents the major tool of remote sensing today.

## III. Literature Review

1. Eunsung Lee, Sangjin Kim, Wonseok Kang, Doochun Seo, and Joonki Paik, "Contrast Enhancement Using Dominant Brightness Level Analysis and Adaptive Intensity Transformation for Remote Sensing Images" [1].

This letter presents a novel contrast enhancement approach based on dominant brightness level analysis and adaptive intensity transformation for remote sensing images. The proposed algorithm computes brightness-adaptive intensity transfer functions using the low-frequency luminance component in the wavelet domain and transforms intensity values according to the transfer function. More specifically, we first perform discrete wavelet transform (DWT) on the input images and then decompose the LL sub band into low-, middle, and high-intensity layers using the log-average luminance. Intensity transfer functions are adaptively estimated by using the knee transfer function and the gamma adjustment function based on the dominant brightness level of each layer. After the intensity transformation, the resulting enhanced image is obtained by using the inverse DWT. Although various histogram equalization approaches have been proposed in the literature, they tend to degrade the overall image quality by exhibiting saturation artifacts in both low- and high-intensity regions. The proposed algorithm overcomes this problem using the adaptive intensity transfer function. The experimental results show that the proposed algorithm enhances the overall contrast and visibility of local details better than existing techniques. The proposed method can effectively enhance any low-contrast images acquired by a satellite camera and is also suitable for other various imaging devices such as consumer digital cameras, photorealistic 3-D reconstruction systems, and computational cameras.

2. H. Demirel, C. Ozcinar, and G. Anbarjafari, "Satellite image contrast enhancement using discrete wavelet transform and singular value decomposition" [6]

In this letter, a new satellite image contrast enhancement technique based on the discrete wavelet transform (DWT) and singular value decomposition has been proposed. The technique decomposes the input image into the four frequency sub-bands by using DWT and estimates the singular value matrix of the low-low sub band image, and, then, it reconstructs the enhanced image by applying inverse DWT. The technique is compared with conventional image equalization techniques such as standard general histogram equalization and local histogram equalization, as well as state-of-the-art techniques such as brightness preserving dynamic histogram equalization and singular value equalization. The experimental results show the superiority of the proposed method over conventional and state-of-the-art techniques.

In this letter, a new satellite image contrast enhancement technique based on DWT and SVD was proposed. The proposed technique decomposed the input image into the DWT sub bands, and,

after updating the singular value matrix of the LL sub band, it reconstructed the image by using IDWT. The technique was compared with the GHE, LHE, BPDHE, and SVE techniques. The visual results on the final image quality show the superiority of the proposed method over the conventional and the state-of-the-art techniques.

3. H. Demirel, G. Anbarjafari, and M. Jahromi, "Image equalization based on singular value decomposition" [7]

In this work, a novel image equalization technique which is based on singular value decomposition (SVD) is proposed. The singular value matrix represents the intensity information of the given image and any change on the singular values change the intensity of the input image. The proposed technique converts the image into the SVD domain and after normalizing the singular value matrix it reconstructs the image in the spatial domain by using the updated singular value matrix. The technique is called the singular value equalization (SVE) and compared with the standard grayscale histogram equalization (GHE) method. The visual and quantitative results suggest that the proposed SVE method clearly outperforms the GHE method.

Various tests on low contrast images, taken from different sources, show the superiority of the SVE technique. A quantitative metric based on KLD which shows the information divergence, between two probability distributions, has been employed to reflect the information loss attained by the SVE and GHE techniques after equalizing various low contrast images. The quantitative results supports the visual results that the quality and the information content of the equalized images are better preserved through the proposed SVE technique.

4. E. Reinhard, M. Stark, P. Shirley, and J. Ferwerda, "Photographic tone re-production for digital images" [8]

A classic photographic task is the mapping of the potentially high dynamic range of real world luminance to the low dynamic range of the photographic print. This tone reproduction problem is also faced by computer graphics practitioners who map digital images to a low dynamic range print or screen. The work presented in this research leverages the time-tested techniques of photographic practice to develop a new tone reproduction operator. In particular, authors use and extend the techniques developed by Ansel Adams to deal with digital images. The resulting algorithm is simple and produces good results for a wide variety of images.

Photographers aim to compress the dynamic range of a scene in a manner that creates a pleasing image. Authors have developed a relatively simple and fast tone reproduction algorithm for digital images that borrows from 150 years of photographic experience. It is designed to follow their practices and is thus well-suited for applications where creating subjectively satisfactory and essentially artifact-free images is the desired goal.

#### IV. Proposed Methodology

Here we describe the step by step procedure of the propose fusion technique based contrast enhancement technique. Flow diagram of which is shown in fig. 1. At first, the image is segmented is taken as input in jpg format. The image is read by MATLAB with the help of 'imread' command and returns the image data in the array RGB ( $M \times N \times 3$ ). Next, the image is converted from RGB to grayscale image with the help of 'rgb2gray' command. The fusion of various gray scale images is maintained by local contrast enhancement method. Three enhancement techniques are used for performing of fusion method. First we use CLAHE method, the

contrast enhancement method can be limited in orderly avoid noise which might be present in the image. In The main idea proposed here is to use DWT to decompose the image into its sub bands and then perform the Laplacian and Gaussian decomposition on the LL sub band of the image. Each of this decomposed part then further goes enhancement. The other three sub bands also undergoes further enhancement as shown in the fig. 2.

Step1: Preprocessing the image. This involves resizing an image and then removing the noise from an image.

Step2 In the first stage of fusion we perform the DWT operation on an image. This decomposes the image into band limited components called HH, HL, LH, LL sub bands.

Step3. LL sub band undergoes decomposition using Laplacian pyramid decomposition and Gaussian pyramid decomposition.

Step4. The second stage of fusion – Again the Laplacian and Gaussian image of the input image is taken. Then we apply the reconstruction of Gaussian and laplacian of the image. The fusion of second stage is completed.

Step5. Final stage of fusion – In this stage, first reconstructed or fused of stage 1 and stage 2 along with the contrast-limited adaptive histogram equalization (CLAHE) of input image is fused together.

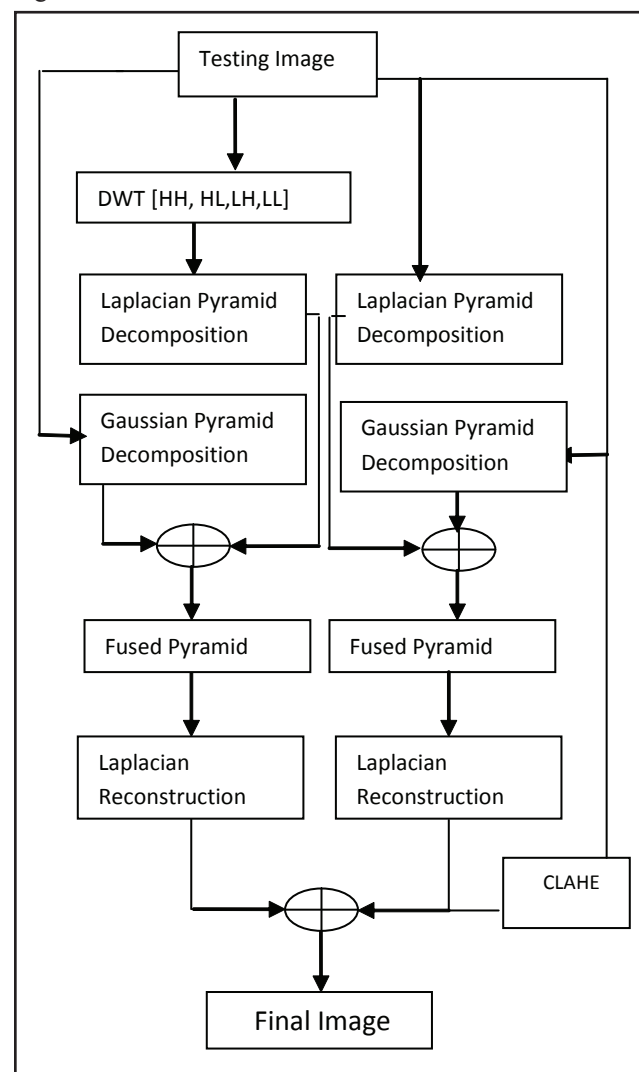


Fig. 2: Flow Chart of Proposed Method



These are the overall steps of proposed method. The flow chat of proposed method all shows the given steps.

## V. Simulation and Result

The proposed algorithm is coded with the MATLAB language. The algorithm steps behind the MATLAB fusion operation are shown in fig. 2. So the proposed program can be interpreted as a function to carry out image enhancement using fusion technique in MATLAB.

Table 1: Comparison of EME

Image	Standard HE	RMSHE	GC-CHE	Demirel's method	DBLA [1]	Proposed Method
Image 1	0.025	0.01	0.125	0.764	0.786	0.816
Image 2	1.172	.497	1.173	2.732	2.746	3.12

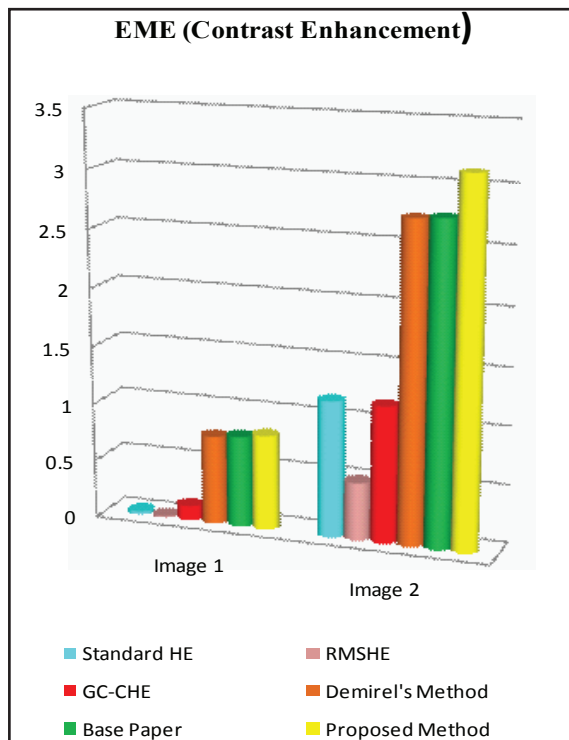


Fig. 3: Graphical Comparison of Different Methods

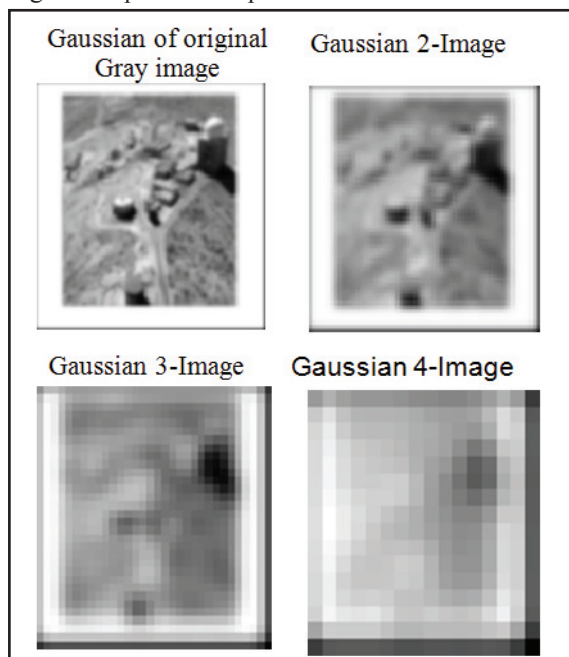


Fig. 4: Image Enhanced Through Different Methods

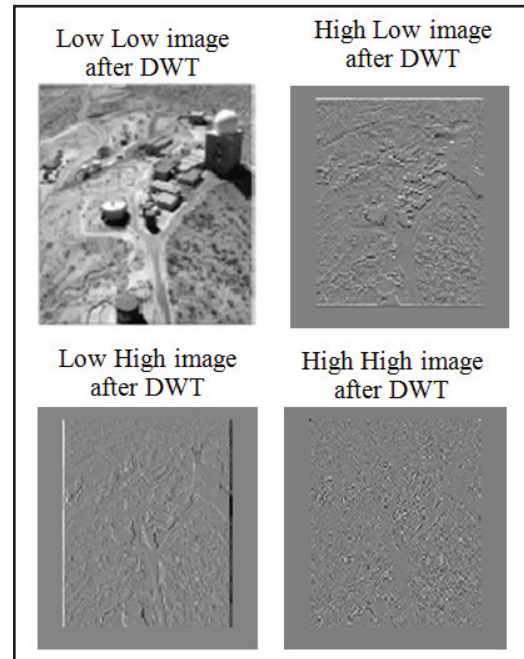


Fig. 5: Image Frequency Subbands Obtained After DWT

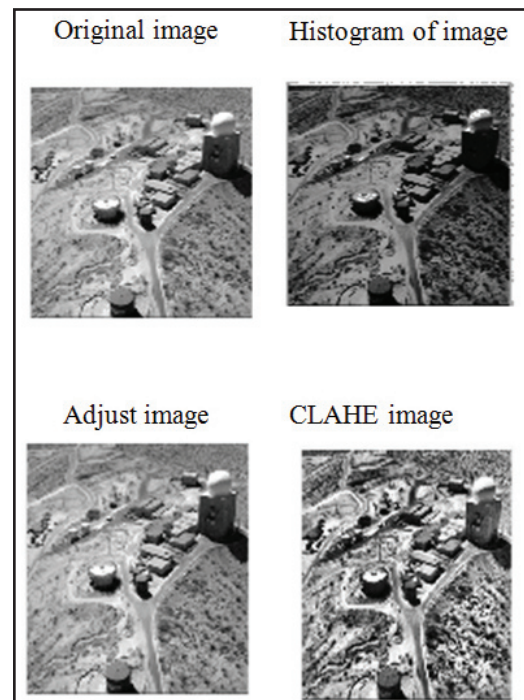


Fig. 6: Gaussian Pyramid Obtained for Aerial Image

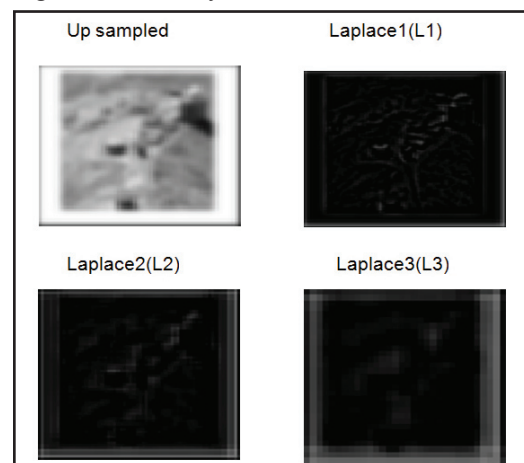


Fig. 7: Laplacian Pyramid Decomposition of Image

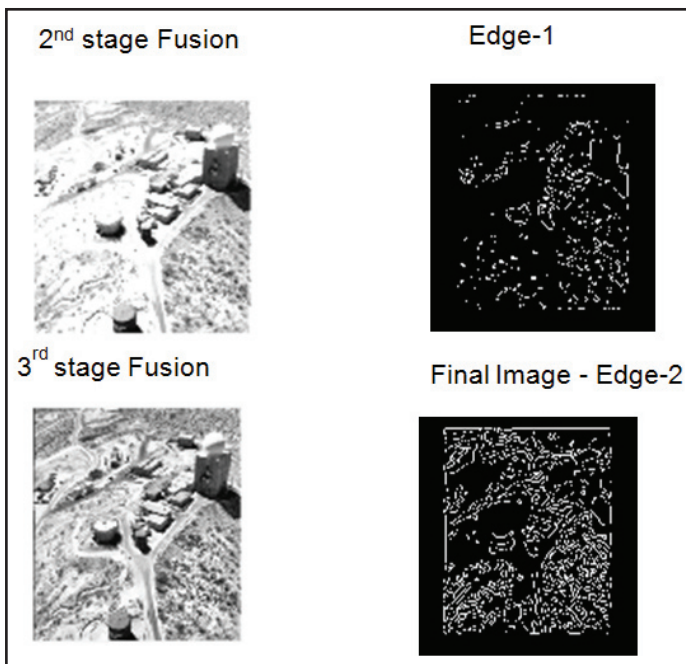


Fig. 8: Enhanced Image Obtained After Fusion and Edge Detection

## VI. Conclusion

In the paper presents a new method of fusion based contrast enhancement for remote sensing and satellite images. Image fusion provides the way to integrate disparate and complementary data to enhance the information apparent in the images as well as to increase the reliability of the interpretation. The fused images were verified for their quality based on a perfect image in each their sets. This methodology is well suited for many applications in different image processing field. The results are promising and image fusion techniques open a new perspective for contrast and quality enhancement in different imaging applications. Image fusion method is tested and comparison is shown to justify the image quality of different images with image enhancement (EME).

## References

- [1] Eunsung Lee, Sangjin Kim, Wonseok Kang, Doochun Seo, Joonki Paik, "Contrast Enhancement Using Dominant Brightness Level Analysis and Adaptive Intensity Transformation for Remote Sensing Images" G. IEEE GEOSCIENCE AND REMOTE SENSING LETTERS, Vol. 10, No. 1, January 2013.
- [2] Amina Saleem, Azeddine Beghdadi, Boualem Boashash: "Image fusion-based contrast enhancement", Journal on Image and Video Processing 2012.
- [3] R. Gonzalez, R. Woods, "Digital Image Processing", 3rd ed. Englewood Cliffs, NJ: Prentice-Hall, 2007.
- [4] Aswathy Mohan, Mary Linda P A, "Image Enhancement Using DWT DCT and SVD", Aswathy Mohan et al. Int. Journal of Engineering Research and Applications, April 2014.
- [5] G. Maragatham, S. Md. Mansoor Roomi, "A Review of Image Contrast Enhancement Methods and Techniques", Research Journal of Applied Sciences, Engineering and Technology, February 15, 2015.
- [6] H. Demirel, C. Ozcinar, G. Anbarjafari, "Satellite image contrast enhancement using discrete wavelet transform and singular value decomposition", Geoscience and remote

sensing letters, Vol. 7, Issue 2, pp. 333-337, 2010.

- [7] H. Demirel, G. Anbarjafari, M. Jahromi, "Image equalization based on singular value decomposition", In Proc. 23rd IEEE Int. Symp. Comput. Inf. Sci., Istanbul, Turkey, Oct. 2008, pp. 1-5.
- [8] E. Reinhard, M. Stark, P. Shirley, J. Ferwerda, "Photographic tone re-production for digital images", In Proc. SIGGRAPH Annu. Conf. Comput. Graph., Jul. 2002, pp. 249-256.
- [9] S. Chen, A. Beghdadi, "Nature rendering of color image based on retinex," In Proc. IEEE Int. Conf. Image Process., Nov. 2009, pp. 1813-1816.
- [10] Y. Monobe, H. Yamashita, T. Kurosawa, H. Kotera, "Dynamic range compression preserving local image contrast for digital video camera," IEEE Trans. Consum. Electron., Vol. 51, No. 1, pp. 1-10, Feb. 2005.
- [11] S. Lee, "An efficient contrast-based image enhancement in the compressed domain using retinex theory," IEEE Trans. Circuit Syst. Video Technol., Vol. 17, No. 2, pp. 199-213, Feb. 2007.
- [12] W. Ke, C. Chen, C. Chiu, "BiTA/SWCE: Image enhancement with bilateral tone adjustment and saliency weighted contrast enhancement," IEEE Trans. Circuit Syst. Video Technol., Vol. 21, No. 3, pp. 360-364, Mar. 2010.
- [13] S. Kim, W. Kang, E. Lee, J. Paik, "Wavelet-domain color image enhancement using filtered directional bases and frequency-adaptive shrinkage," IEEE Trans. Consum. Electron, vol. 56, no. 2, pp. 1063- 1070, May 2010.
- [14] S. S. Agaian, B. Silver, K. A. Panetta, "Transform coefficient histogram-based image enhancement algorithms using contrast entropy," IEEE Trans. Image Process., Vol. IP-16, No. 3, pp. 741-758, Mar. 2007.
- [15] Computer Vision Group-University of Granada (CVG-UGR) Image Database. [Online] Available: <http://decsai.ugr.es/cvg/dbimagenes>.
- [16] Pranay Yadav, "Color Image Noise Removal by Modified Adaptive Threshold Median Filter for RVIN", Electronic Design, Computer Networks & Automated Verification, 2015 Conference, pp. 175-180, Jan. 2015.
- [17] Prany Yadav, Parool Singh, "Color Impulse Noise Removal by Modified Alpha Trimmed Median Mean Filter for FVIN", IEEE International Conference on Computational Intelligence and Computing (IEEE-ICCIC) Coimbatore-641659, pp. 1 - 8, Dec - 2014.
- [18] Sharma, S., Yadav, P, "Removal of Fixed Valued Impulse Noise by Improved Trimmed Mean Median Filter", IEEE International Conference on Computational Intelligence and Computing (IEEE-ICCIC) Tamilnadu, (IEEE-ICCIC), pp. 1 - 8, Dec 2014.